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Anamylopsora altaica sp. nov. from Northwestern China

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Abstract—*Anamylopsora altaica*, collected from rocks in the Hot Spring Valley Forest Park in the Altay Mountains, Xinjiang, Northwestern China, is described as a new species, based on morphological and chemical characteristics, as well as ITS DNA sequence data. The new lichen species is characterized by its crowded, overlapping squamules with upturned margins, crowded globose apothecia with eight simple hyaline spores per ascus, and the presence of psoromic acid. A detailed description and colour photographs are provided.

Key words—*Anamylopsoraceae*, *Baeomycetaceae*, *Baeomycetales*

Introduction

The lichen biota of Northwestern China is rich, with more than 750 species belonging to c. 150 genera (Wei 1991, Abbas & Wu 1998, Abbas & al. 2001, Guo 2005). One lichen from temperate and tropical regions, *Anamylopsora pulcherrima* (Vain.) Timdal, type of the monotypic genus *Anamylopsora* Timdal (Huneck & Elix 1993, Lumbsch & al. 1995), has been collected in China from Gansu (Magnusson 1940, Timdal 1991, Wei 1991), Neimenggu (Magnusson 1942, Timdal 1991, Wei 1991) and Xizang (Obermayer 2004). *Anamylopsora pulcherrima* was originally described as *Lecidea pulcherrima* Vain. (Vainio 1888), subsequently combined as *Psora pulcherrima* (Vain.) Elenkin (Elenkin 1904), and finally transferred to *Anamylopsora* by Timdal (1991).

A comparison of anatomical, chemical, and ontogenetical characters initially supported *Anamylopsora* within a new family *Anamylopsoraceae*

Lumbsch & Lunke (*Agyriineae*, *Lecanorales;* Lumbsch & al. 1995), but more recent phylogenetic analyses place the genus in *Baeomycetaceae*, *Baeomycetales*. *Anamylopsora* specimens collected recently from northwestern China have been examined and are described here as a new species, *Anamylopsora altaica*.

Materials & methods

Specimens of the lichen *Anamylopsora* were collected by from rocks in the Hot Spring Valley Forest Park and in the Two-River Source Nature Reserve, Altay Mountains, Xinjiang, Northwestern China, and have been deposited in the Lichen Section of the Botanical Herbarium, Arid land Lichen Research Center of Western China, Xinjiang University, Urumqi, China (XJU).

Morphology

The specimens were examined using a Nikon Eclipse E200 stereo-microscope. Sections were cut by hand using a razor blade and were mounted and observed in water and iodine. The structure and hymenial characters were studied with a Zeiss Axioskop 2 plus light microscope and photographed using a Nikon Digital Camera D50. Chemical constituents were identified by colour spot tests and thin-layer chromatography using solvent system C (Orange & al. 2010).

DNA extraction, amplification, sequencing

Thallus fragments with ascomata were removed from the holotype and two other specimens for DNA extraction using the DNAsecure Plant DNA Kit following the manufacturer's protocol. The nrITS (ITS1+5.8S+ITS2) region was amplified in a polymerase chain reaction according to Han & al. (2013) as modified in Abbas & al. (2014) using the primers ITS1F (Gardes & Bruns 1993) with ITS4 (White & al. 1990). The DNA was amplified in a 30 µL volume containing 0.75 units of TransStart Taq Polymerase, 3.5 µL buffer, 0.5 µl of a 5 µM primer solution, 2 µL each per 2.5 mM dNTP solution, and 1 µL of genomic DNA. The PCR mixture was cycled at 95°C for 5 min; then 35 cycles at 94°C for 30 s, 55°C for 45 s, and 72°C for 1 min; with a final extension of 72°C for 10 min. PCR products were screened on 1% agarose gels stained with ethidium bromide and sequenced by Shenggong Inc. in Shanghai. Newly obtained sequences were submitted to GenBank.

We aligned ITS sequences from our three specimens and the 17 GenBank representatives using ClustalW and Muscle implemented in MEGA7 (Kumar & al. 2016). The final matrix, submitted to TreeBase, is available by request from the corresponding authors.

The evolutionary history was inferred by using the Neighbour-joining (NJ) method implemented in MEGA7 (Saitou & Nei 1987, Tamura & al. 2004, Kumar & al. 2016). Bootstrap replication was set to 1000, and the evolutionary distances were computed using the Maximum Composite Likelihood method and were in units of the number of base substitutions per site. Rate variation among sites was modeled with a gamma distribution (shape parameter = 5). The Minimum Evolution (ME) tree was searched

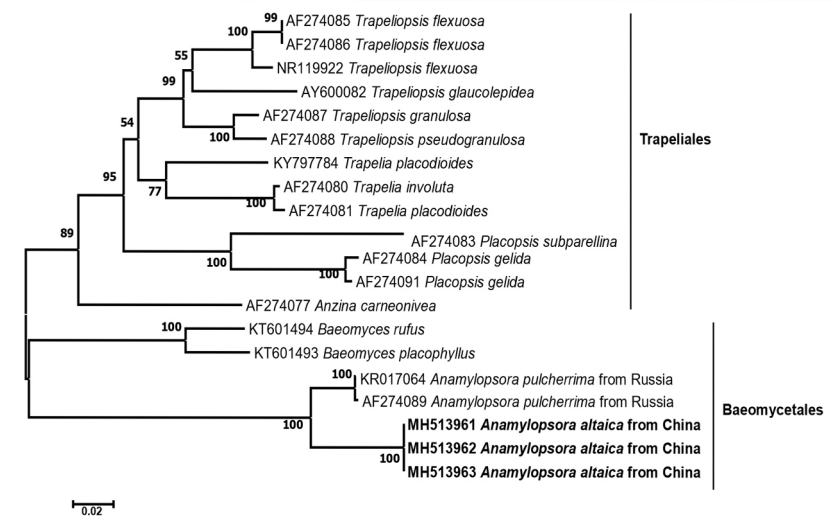

Fig.1 Neighbour-joining (NJ) phylogenetic tree of ITS sequences for *Anamylopsora altaica* and similar species retrieved from GenBank. Numbers above branches indicate values >50% from 1000 bootstrap replicates of NJ analyses.

using the Close-Neighbor-Interchange (CNI) algorithm at a search level of 1. The initial tree was generated by the Neighbor-joining algorithm. The gaps were removed for each sequence pair.

ITS sequence analysis and phylogeny

The entire ITS region was successfully sequenced for the holotype specimen and two additional specimens. A Blast search was conducted, and GenBank sequences from taxa sharing the most similarity with our new sequences were selected (Timdal 1991, Lumbsch & al. 1995). Partial sequences of the 3′ end in SSU region and the 5′ end in LSU region were included in the data submitted to GenBank.

The final nrITS alignment included 20 sequences representing 13 taxa and comprised 513 sites, of which 441 were constant, 18 were parsimony-uninformative, and 54 were parsimony-informative. There were no ambiguously aligned regions.

ITS sequences support our specimens in *Anamylopsora* with close affinities to the existing *A. pulcherrima* sequences in GenBank (91% with KR017064; 90% with AF274089). The evolutionary history was inferred as the NJ tree. The

phylogeny clearly shows the relationship of the new species with closely related species (Fig.1). *Anamylopsora* and *Baeomyces* cluster together in a monophyletic group within *Baeomycetales*, which is a sister group to the *Trapeliales*.

Taxonomy

Anamylopsora altaica Ahat, A. Abbas, S.Y. Guo & Tumur, **sp. nov.** Fig. 2

FungalName FN570571

Differs from *Anamylopsora pulcherrima* by its overlapping squamules, its crowded globulose apothecia concentrated along the squamule margins, and the presence of psoromic acid and absence of alectorialic acid.

Type: China. Xinjiang: Altay Mountains, Hot Spring Valley Forest Park, 47°33′52″N 88°41′29″E, alt. 1030 m, 17 May 2014, A. Tumur & A. Abbas Altay-20140041 (**Holotype,** XJU; GenBank MH513961; **Isotype,** HMAS-L).

Etymology: The new species is named after the Altay Mountains, where the holotype was collected.

Thallus irregularly squamulose, usually appressed on siliceous rocks; squamules ≤1(–2.5) mm diam., intensively overlapping, without soredia or isidia, pale-green to light yellow-green, with or without a light frosting of pruina on the upper surface; thallus margin entire to subentire, usually upturned; upper surface white to whitish-grey pruinose; lower surface white to dirty white, without rhizines; upper cortex 55–95 µm thick, brown to light-brown; algal layer 135–195 µm thick, continuous, algal cells 8–12 µm diam., photobiont *Trebouxia* sp.; medulla 190–280 µm thick; lower cortex paraplectenchymatous, 30–65 µm thick.

Apothecia lecideine, ≤1(–1.5) mm diam.; often >10 globose apothecia in clusters ≤12 mm diam. attached to the squamule margins; disc brown to dark brown, dull, epruinose; epihymenium faint yellow to light brown, 25–30 µm high; hymenium 95–115 µm high. Paraphyses simple or sparingly branched. Hypothallus colourless, 70–115 µm high. Asci narrowly clavate to subcylindrical, lacking an ocular chamber, inamyloid, 8-spored, 50–70 × 12–16 µm. Ascospore hyaline, simple, ellipsoid, thin-walled, 9–12 × 5–8 µm, usually with 1–3 oil drop(s) and a warty surface. Pycnidia occurring at the squamule margins, rod-shaped, ≤0.4 mm diam., dark brown to black. Conidia hyaline narrowly ellipsoid to shortly bacilliform, 3 × 1 µm.

Color tests—Thallus cortex PD+ orange, K+ yellow, C–, KC–, UV–. Thallus medulla PD–, K–, C–, KC–. Apothecial disks I+ blue, K–, C–, UV–.

Secondary metabolites—Only psoromic acid detected by TLC.

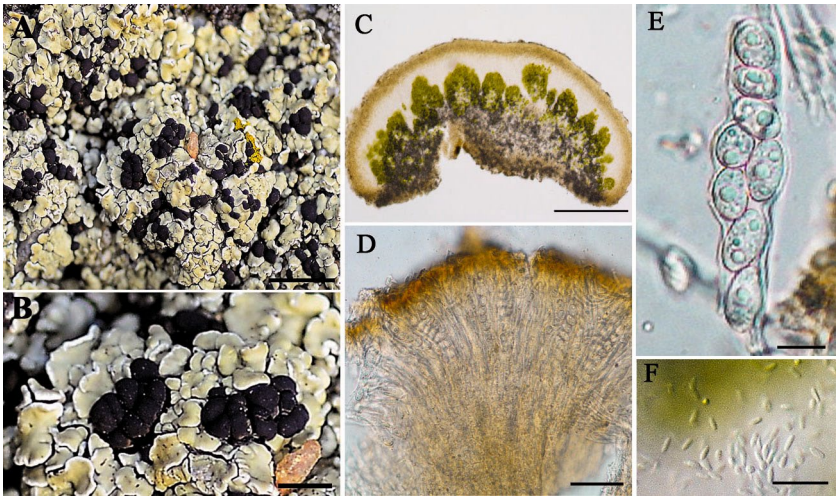

Fig. 2 *Anamylopsora altaica* (Holotype, XJU Altay-20140041). A. General habit; B. Apothecia; C. Interrupted algal layer in thin section of the thallus; D. Section of apothecium; E. Ascus and spores; F. Conidia. Scale bars: A = 10 mm; B = 1 mm; C = 200 μm; D = 50 μm; E = 20 μm; F = 5 μm.

Ecology—*Anamylopsora altaica* grows at altitudes of c. 900–1200 m in montane forests, on semi-shaded granite rocks, in association with *Aspicilia concorta,* and *Acarospora* sp. The species is known only from Xinjiang, Northwestern China; although rare in the type locality, it may occur in other regions in central Asia.

Additional specimens examined—**CHINA. Xinjiang: Altay Mountains**, Hot Spring Valley Forest Park, 47°50′23″N 88°42′51″E, alt. 960 m, 26 May 2014, Anwar Tumur & Abdulla Abbas 20140032 (XJU-NALH, GenBank MH513962); 47°03′41″N 88°67′06″E, alt. 1022 m, Anwar Tumur & Abdulla Abbas 20140040 (XJU-NALH); Two-River Source Nature Reserve, 47°45′09″N 88°34′48″E, alt. 1187 m, 20 July 2015, Anwar Tumur & Abdulla Abbas 20150068 (XJU-NALH; GenBank MH513963).

Comments—*Anamylopsora altaica* and *A. pulcherrima* are distinguished by thallus color, apothecial characters, secondary substances, and substrate. *Anamylopsora pulcherrima* usually has yellow lobes and black apothecia, with squamules having a strongly fissured upper side, a purplish-red lustrous thallus with a lacinulate appearance, and produces alectorialic acid; additionally, *A. pulcherrima* grows at higher altitudes (c. 2700–3000 m), on calciferous stone or calcareous soil in association with *Phycia kansuensis, Psorotichia nigra,* and several other small lichens (Timdal 1991, Lumbsch & al.1995). *Lecidea hedinii*

and *L. undulata,* which were synonymised with *Anamylopsora pulcherrima* by Timdal (1991), also resemble *A. altaica*, but differ in their 'flavescenti-testaceus' thallus colour and areolate shape, their K+ (orange) cortex, and their infrequent, smaller (0.3–0.5 mm), dirty reddish apothecia (Magnusson 1942).

Anamylopsora and *Baeomyces* both exhibit a similar ascoma ontogeny and the same type of conidiophores, although these similarities may well result from convergent evolution (Lumbsch & Huhndorf 2010). However, although closely related by molecular phylogeny, they differ in the ascus type. *Anamylopsora altaica* resembles some species of *Trapeliopsis* and *Trapelia*, e.g., *Trapelia placodioides*, but has slightly smaller lobes [<3 mm] and a smooth upper surface.

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Literature cited

Abbas A, Wu JN. 1998. Lichens of Xinjiang. Sci-Tec & Hygiene Publishing House of Xinjiang, Urumqi.

Abbas A, Mijet H, Tumur A, Wu JN. 2001. A checklist of the lichens of Xinjiang, China. Harvard Papers in Botany 5: 359–370.

Abbas A, Guo SY, Ababaikeli G, Abdulla A, Xahidin H. 2014. *Diploschistes xinjiangensis*, a new saxicolous lichen from northwest China. Mycotaxon 129: 465–471. https://doi.org/10.5248/129.465

Elenkin AA. 1904. Schedae zu Lichenes Florae Rossiae, Fasc.II–IV. Acta Horti Petropolitani 24: 1–118.

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes—application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Guo SY. 2005. Lichens. 31–82, in: WY Zhuang (ed.). Fungi of Northwestern China. Ithaca, New York, Mycotaxon Ltd.

Han LF, Zhang YY, Guo SY. 2013. *Peltigera wulingensis*, a new lichen (*Ascomycota*) from north China. Lichenologist 45: 329–336. https://doi.org/10.1017/s0024282912000837

Huneck S, Elix JA. 1993. The chemistry of the lichens *Anamylopsora pulcherrima* and *Tephromela armeniaca*. Herzogia 9: 647–651.

Kumar S, Stecher G, Tamura K. 2016. MEGA7: molecular evolutionary genetics analysis version 7.0 for bigger datasets. Molecular Biology and Evolution 33: 1870–1874. https://doi.org/10.1093/molbev/msw054

Lumbsch HT, Huhndorf SM. 2010. Myconet volume 14. Part one. Outline of *Ascomycota*—2009. Fieldiana Life and Earth Sciences 16(7): 1–65. https://doi.org/10.3158/1557.1

Lumbsch HT, Lunke T, Feige GB, Huneck S. 1995. *Anamylopsoraceae*—a new family of lichenized ascomycetes with stipitate apothecia (*Lecanorales*: *Agyriineae*). Plant Systematics and Evolution 198: 275–286. https://doi.org/10.1007/bf00984742

Magnusson AH. 1940. Lichens from Central Asia. Reports from the Scientific Expedition to the North-West Provinces of China under the leadership of Dr. Sven Hedin. The Sino-Swedish Expedition. Publ. 13, XI. Botany 1. Stockholm.

Magnusson AH. 1942. Lichens from Central Asia. Reports from the Scientific Expedition to the North-West Provinces of China under the leadership of Dr. Sven Hedin. The Sino-Swedish Expedition. Publ. 22, XI. Botany 2. Stockholm.

Obermayer W. 2004. Additions to the lichen flora of the Tibetan region. Bibliotheca Lichenologica 88: 479–526.

Orange A, James PW, White FJ. 2010. Microchemical methods for the identification of lichens, 2nd ed. British Lichen Society, London.

Saitou N, Nei M.1987. The neighbor-joining method: a new method for reconstructing phylogenetic trees. Molecular Biology and Evolution 4: 406–425. https://www.ncbi.nlm.nih.gov/pubmed/3447015

Tamura K, Nei M, Kumar S. 2004. Prospects for inferring very large phylogenies by using the neighbor-joining method. Proceedings of the National Academy of Sciences (USA) 101: 11030–11035. https://doi.org/10.1073/pnas.0404206101

Timdal E. 1991. *Anamylopsora*, a new genus in the Lecideaceae. Mycotaxon 42: 249–254.

Vainio EA. 1888. Plantae Turcomanicae a G. Radde et A. Walter collectae. II. Lichenes examinavit et enumeravit. Acta Horti Petropolitani 10(2): 551–562.

Wei JC. 1991. An enumeration of lichens in China. International Academic Publishers, Beijing.

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis & al. (eds), PCR Protocols: a Guide to Methods and Applications. San Diego, Academic Press. https://doi.org/10.1016/B978-0-12-372180-8.50042-1